

CLAIMS

IN THE CLAIMS:

1610 1. A software-based, flexible computer architecture for communication and cooperation among distributed electronic agents, the architecture contemplating a distributed computing system comprising:

a plurality of service-providing electronic agents;

1615 a distributed facilitator agent functionally distributed across at least two computer processes, the facilitator agent capable of bi-directional communications with the plurality of service-providing electronic agents, the facilitator agent including:

an agent registry that declares capabilities for each of the plurality of service-providing electronic agents currently active within the distributed computing environment; and

1620 a facilitating engine operable to interpret a service request as a base goal, the facilitating engine further operable coordinate a suitable delegation of sub-goal requests to best complete the requested service request.

1625 2. A software-based, flexible computer architecture as recited in claim 1 wherein the distributed facilitator agent includes a plurality of single process facilitator agents each executing within a separate computer process, each of the single process facilitator agents being bi-directionally coupled with at least one other single
1630 process facilitator agent.

3. A software-based, flexible computer architecture as recited in claim 2 wherein each single process facilitator agent has

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any necessary facilitating functionality, a specific single process
1635 facilitator including:

a specific agent registry that declares capabilities for each of
the plurality of service-providing electronic agents currently active
within the process wherein the specific single process is executing,
the specific agent registry further declaring capabilities made
1640 available to the specific single process facilitator agent through the
at least one other single process facilitator agent bi-directionally
coupled with the specific single process facilitator agent; and

a specific facilitating engine operable to interpret a service
request as a base goal, the facilitating engine further operable to
1645 determine sub goals required to complete the base goal; the
facilitator engine further operable to select service providing agents
best capable of complying the sub goal and assigning the sub goals
thereto.

1650 4. A software-based, flexible computer architecture as
recited in claim 3 wherein at least two of the plurality of single
process facilitator agents reside upon separate computer systems.

5. A computer architecture as recited in claim 4, wherein the
1655 basis for the computer architect is an Interagent Communication
Language (ICL) enabling agents to perform queries of other agents,
exchange information with other agents, and set triggers within other
agents, the ICL further defined by an ICL syntax supporting compound
goal expressions such that goals within a single request provided
1660 according to the ICL syntax may be coupled by a conjunctive operator, a
disjunctive operator, a conditional execution operator, and a parallel

disjunctive operator that indicates that disjunctive goals are to be performed by different agents.

1665 6. A computer architecture as recited in claim 5, wherein the ICL is computer platform independent.

1670 7. A computer architecture as recited in claim 6 wherein the ICL is independent of computer programming languages in which the plurality of agents are programmed.

1675 8. A computer architecture as recited in claim 7 wherein the ICL syntax supports explicit task completion constraints within goal expressions.

 9. A computer architecture as recited in claim 8 wherein possible types of task completion constraints include use of specific agent constraints and response time constraints.

1680 10. A computer architecture as recited in claim 8 wherein the ICL syntax supports explicit task completion advisory suggestions within goal expressions.

1685 11. A computer architecture as recited in claim 5 wherein the ICL syntax supports explicit task completion advisory suggestions within goal expressions.

 12. A computer architecture as recited in claim 5 wherein each autonomous service-providing electronic agent defines and publishes a

1690 set of capability declarations or solvables, expressed in ICL, that describes services provided by such electronic agent.

13. A computer architecture as recited in claim 12 wherein an electronic agent's solvables define an interface for the electronic agent.

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14. A computer architecture as recited in claim 1 wherein the distributed facilitator agent is formed in a hierarchical topology.

15. A computer architecture as recited in claim 14
1700 wherein the hierarchical topology includes a top level facilitator agent and at least one other facilitator agent registered within the top level facilitator agent, the top level facilitator agent operable to directly manage those service-providing agents registered within the top level facilitator agent and indirectly manage those service-
1705 providing agents registered within the at least one other agent registered with the top level facilitator agent.

16. A computer architecture as recited in claim 15
1710 wherein the top level facilitator agent and the at least one other facilitator agent are executing on different computer systems.

17. A computer architecture as recited in claim 15
1715 wherein the at least one other facilitator agent is installed for a specific computer user.

18. A computer architecture as recited in claim 15 wherein the at least one other facilitator agent is installed for a specific group of users.

1720 19. A computer architecture as recited in claim 15 wherein the at least one other facilitator agent is installed for a specific computer application.

1725 20. A computer architecture as recited in claim 1 wherein the distributed facilitator agent includes a planning component executing within a first computer process and an execution component executing within a second computer process.

1730 21. A computer architecture as recited in claim 20 wherein the planning component is one of a plurality of synchronized planning components each executing with separate computer processes, whereby the computer architecture provides a more robust operating environment due to redundancy of the planning component functionality of the distributed facilitator agent.

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22. A software-based flexible computer architecture for communication and cooperation among distributed electronic agents, the architecture contemplating a distributed computing system comprising:

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- a plurality of service providing electronic agents;
- at least one facilitator agent capable of receiving a service requests in the form of a base goal from a client agent in an interagent communication language and capable of determining

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1745 sub goals necessary to accomplish the base goal, the facilitator operable to allocate each sub-goal to at least one server agent capable of accomplishing the sub-goal as determined by the registry; and

at least one agent capable of making a request directly to a
1750 server agent as a peer to peer communication for accomplishment of at least one of the sub-goals.

23. A software based, flexible computer system as recited in claim 22 wherein the peer to peer communication is in a
1755 language other than an interagent communication language.

24. A software based, flexible computer system as recited in claim 22 wherein the peer to peer communication is bi-directional.
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25 A software based, flexible computer system as recited in claim 22 wherein the agent operable to make said peer to peer service request is said facilitator agent.

1765 26. A distributed facilitator agent functionally distributed across at least two computer processes, the distributed facilitator agent arranged to coordinate cooperative task completion within a distributed computing environment having a plurality of autonomous service-providing electronic agents, the distributed facilitator agent comprising:

1770 an agent registry that declares capabilities of service-providing electronic agents currently active within the distributed computing environment; and

a facilitating engine operable to parse a service request in order to interpret a compound goal set forth therein, the service request formed according to an Interagent Communication Language (ICL), the facilitating engine further operable to coordinate a suitable delegation of sub-goal requests to complete the requested service.

27. A facilitator agent as recited in claim 26, wherein the facilitating engine is capable of modifying the goal satisfaction plan during execution, the modifying initiated by events such as new agent declarations within the agent registry, decisions made by remote agents, and information provided to the facilitating engine by remote agents.

28. A facilitator agent as recited in claim 26 wherein the agent registry includes a symbolic name, a unique address, data declarations, trigger declarations, task declarations, and process characteristics for each active agent.

29. A facilitator agent as recited in claim 26 wherein the facilitating engine is operable to install a trigger mechanism requesting that a certain action be taken when a certain set of conditions are met.

30. A facilitator agent as recited in claim 29 wherein the trigger mechanism is a communication trigger that monitors communication events and performs the certain action when a certain communication event occurs.

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1800 31. A facilitator agent as recited in claim 29 wherein the trigger mechanism is a data trigger that monitors a state of a data repository and performs the certain action when a certain data state is obtained.

1805 32. A facilitator agent as recited in claim 31 wherein the data repository is local to the facilitator agent.

33. A facilitator agent as recited in claim 26 wherein the data repository is remote from the facilitator agent.

1810 34. A facilitator agent as recited in claim 29 wherein the trigger mechanism is a task trigger having a set of conditions.

1815 35. A facilitator agent as recited in claim A1, the facilitator agent further including a global database accessible to at least one of the service-providing electronic agents.

1820 36. A facilitator agent as recited in claim A1 wherein the distributed facilitator agent includes a plurality of single process facilitator agents each executing within a separate computer process, each of the single process facilitator agents being bi-directionally coupled with at least one other single process facilitator agent.

1825 37. A facilitator agent as recited in claim 36 wherein each single process facilitator agent has any necessary facilitating functionality, a specific single process facilitator including:

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a specific agent registry that declares capabilities for each of the plurality of service-providing electronic agents currently active within the process wherein the specific single process is executing, the specific agent registry further declaring capabilities made
1830 available to the specific single process facilitator agent through the at least one other single process facilitator agent bi-directionally coupled with the specific single process facilitator agent; and

a specific facilitating engine operable to parse a service request in order to interpret an arbitrarily complex goal set forth
1835 therein, the facilitating engine further operable to construct a goal satisfaction plan including the coordination of a suitable delegation of sub-goal requests to best complete the requested service.

38. A facilitator agent as recited in claim 37 wherein at
1840 least two of the plurality of single process facilitator agents reside upon separate computer systems.

39. A facilitator agent as recited in claim 38 wherein the distributed facilitator agent is formed in a hierarchical topology.
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40. A facilitator agent as recited in claim 39 wherein the hierarchical topology includes a top level facilitator agent and at least one other facilitator agent registered within the top level facilitator agent, the top level facilitator agent operable to directly
1850 manage those service-providing agents registered within the top level facilitator agent and indirectly manage those service-providing agents registered within the at least one other agent registered with the top level facilitator agent.

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1855 41. A facilitator agent as recited in claim 40 wherein the
top level facilitator agent and the at least one other facilitator agent
are executing on different computer systems.

1860 42. A facilitator agent as recited in claim 40 wherein the
at least one other facilitator agent is installed for a specific
computer user.

1865 43. A facilitator agent as recited in claim 40 wherein the
at least one other facilitator agent is installed for a specific group of
users.

1870 44. A facilitator agent as recited in claim 40 wherein the
at least one other facilitator agent is installed for a specific
computer application.

1875 45. A facilitator agent as recited in claim A1 wherein the
distributed facilitator agent includes a planning component
executing within a first computer process and an execution
component executing within a second computer process.

1880 46. A facilitator agent as recited in claim 45 wherein the
planning component is one of a plurality of synchronized planning
components each executing with separate computer processes,
whereby the computer architecture provides a more robust
operating environment due to redundancy of the planning
component functionality of the distributed facilitator agent.

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47. A facilitator agent for coordinating cooperative task completion within a distributed computing environment having a plurality of autonomous service-providing electronic agents, the distributed facilitator agent comprising

a registry of capabilities of the service providing agents; and
a facilitating engine operable determine a set of sub goals necessary to accomplish the base goal, and then allocate such sub-goals to those agents capable of accomplishing the base goals as determined by the registry, said facilitator further capable of initiating a direct peer to peer communication of at least one sub-goal.

48. A facilitator as set forth in claim 47 wherein the peer to peer communication is in a language other than an interagent communication language.

49. A facilitator as set forth in claim 47 wherein the facilitator agent is functionally distributed across at least two electronic agents.

50. A facilitator as set forth in claim 49 wherein the peer to peer communication is between said distributed facilitator agents.

51. A computer-implemented method for providing cooperative task completion within a distributed computing environment, the distributed computing environment including a plurality of autonomous electronic agents, the distributed computing environment supporting an Interagent Communication Language, the computer implemented method comprising the acts of:

1915 providing a plurality of synchronized agent registries each declaring capabilities of service-providing electronic agents currently active within the distributed computing environment, the plurality of synchronized agent registries each resident within a separate computer process;

interpreting a service request in order to determine a base goal, the service request adhering to an Interagent Communication Language (ICL), the act of interpreting including the sub-acts of:

- 1920 determining sub-goals required in completing the base goal,
- selecting service-providing electronic agents from an available one of the plurality of agent registries suitable for performing the determined sub-goals, and
- ordering a delegation of sub-goal requests to best complete
- 1925 the requested service; and
- implementing the base goal satisfaction plan.

52. A computer implemented process as recited in claim 51 wherein the step of interpreting a service request is controlled by a computer process separate from the computer processes wherein the plurality of

1930 synchronized agent registries reside.

53. A computer implemented process for providing coordinated task completion within a distributed computing environment, the distributed computing environment including a plurality of autonomous electronic

1935 agents, the computer implemented method comprising the steps of:

- providing at least one agent registry including capabilities of service providing electronic agents;
- interpreting a service request in the form of a base goal, the service
- 1940 request being in an interagent communication language;

determining a plurality of sub goals necessary to accomplish the base goal;

selecting from said registry at least one service providing agent capable of completing said sub goals;

1945 delegating at least one sub goal as a peer to peer service request directly from a service requesting agent to a service providing agent; and

delegating any remaining sub goals as service request in the interagent communication language to the selected agents capable of completing the remaining sub-goals.

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54. A computer-implemented method for providing cooperative task completion within a distributed computing environment, the distributed computing environment including a plurality of autonomous electronic agents, the distributed computing environment supporting a dynamically expandable Interagent Communication Language ("ICL"),
1955 the computer implemented method comprising the acts of:

providing a plurality of synchronized agent registries each declaring a set of functional capabilities for one or more of the autonomous electronic agents, each of the synchronized agent registries
1960 being resident within a separate computer process;

receiving a service request adhering to the ICL;

determining one or more sub-goal requests in order to perform the service request;

determining a delegation plan that assigns the sub-goal requests to
1965 one or more of the autonomous electronic agents, based upon the capabilities declared in one or more of the agent registries; and

implementing the delegation plan.

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55. A computer implemented method as recited in claim 54
1970 wherein the act of providing a plurality of agent registries further includes
replicating at least a portion of one or more of the synchronized agent
registries across a plurality of separate computer processes.

56. A computer implemented method as recited in claim 54
1975 wherein the act of implementing the delegation plan is controlled by a
computer process separate from the computer processes wherein the
plurality of synchronized agent registries reside.

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